

# Animal Fats

The United States is the world's leading producer of animal fats, including lard and edible tallow and inedible tallow and grease. We produce much more of both types of fats than we can consume domestically. In 1988, U.S. production of lard and edible tallow totaled about 1.2 billion pounds; production of inedible tallow and grease came to more than 6 billion pounds. (The latter category is a technical one that means only that the fats cannot be sold for human consumption in the United States. They are exported for a variety of uses in other countries and are used in animal feeds in this country.) U.S. exports of inedible animal fats in 1988 totaled about 2.8 billion pounds, or 45 percent of our total production.

One of the initial assignments of the Eastern regional center was to find new or expanded ways to utilize animal fats, which were then in surplus, as they are today. The most important industrial use of inedible fats 50 years ago was in making soap, which swallowed up nearly 1-1/2 billion pounds of inedible tallow and grease a year. As for edible animal fats, Americans in 1940, still happily unconscious of their cholesterol levels, consumed more lard than they did vegetable oils. Both these uses, of course, have been shrinking during the last half century, and scientists searching for ways to get rid of animal fat surpluses have been fighting an uphill battle. They have been successful nevertheless in finding many new and important markets for animal fats, amounting to hundreds of millions of dollars. And their quest is far from done.

Even while the Wyndmoor laboratory was under construction, its director-designate wondered if ascorbic acid, or vitamin C, might be an effective antioxidant in fat if it were made more fat-soluble. A colleague managed after many difficulties to produce a new compound from the vitamin and a long-chain fatty acid. The result, ascorbyl palmitate, is used today as a dietary supplement and as an antioxidant in vegetable oils. The patent was the first issued to ERRC staff members.

The ERRC team also used hydrogen peroxide to insert an atom of oxygen in the hydrocarbon portion of fatty acids, a process called epoxidation. What the addition of oxygen did was convert unsaturated fats and oils into valuable plasticizers and stabilizers. They blend well with commercial resins, don't evaporate, and minimize the need for other stabilizers, which may be toxic and make plastics hazy or opaque.

Besides creating a new market for fats and oils, the discovery helped create a billion-dollar plastics industry. Most notably, it transformed vinyl plastics, which were hard and rigid and decomposed in sunlight, into soft, flexible, long-lasting plastics, suitable for floor coverings, auto upholstery, and the 101 other uses of vinyl plastics today. Over the last decade, commercial production of epoxidized ester plasticizers derived from fats and oils has been about 50,000 tons per year. What began as a way to use animal fats, however, eventually turned into a way to use vegetable oils. Some 75 percent of the plasticizers for flexible vinyl today are made from soybean oil.

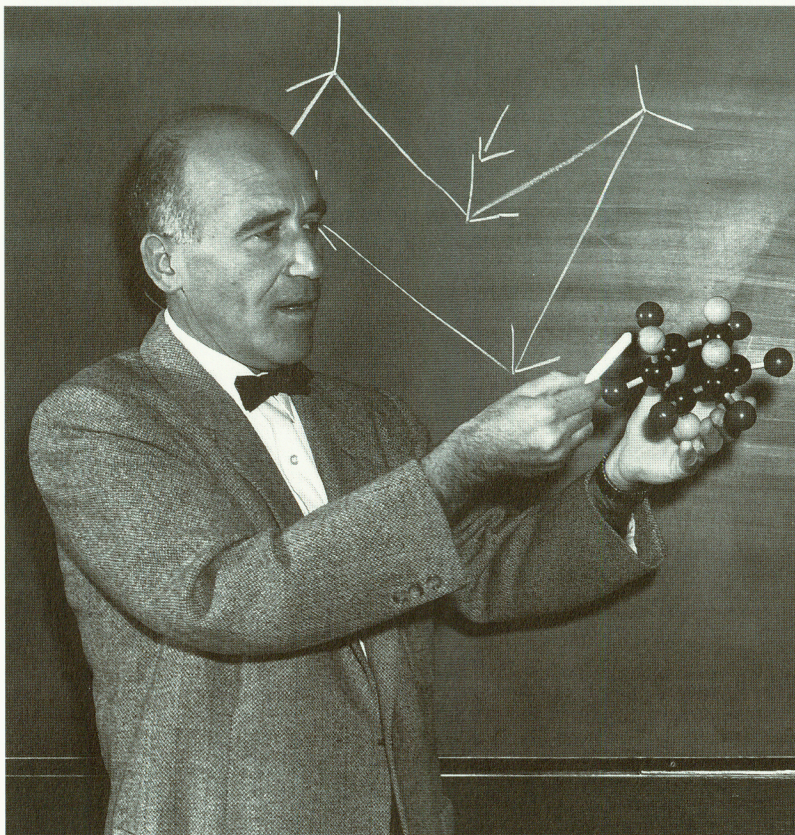
The greatest single use found by researchers for inedible tallow and grease was in animal feeds. It resulted from a contract sponsored by ERRC and carried out by a private laboratory. The researchers determined the nutritional advantages of including additional fat in dog and poultry feed and developed methods for stabilizing it and incorporating it in the feeds. Other labs later extended the studies of beef cattle, hogs, turkeys, and sheep, all of which were found to thrive on feed containing levels of fat as high as 8 percent.

There were other benefits as well. Adding fat to feed eliminated dust, cutting down on the risk of fires and explosions. Fats were also found to help preserve the nutritive value of mixed feeds during storage by reducing the oxidation of carotene, a precursor of vitamin A. A study conducted in the mid-1950's at the Western center showed that after 16 weeks of storage, alfalfa meal lost 62 percent of its original carotene; meal fortified with 5 percent tallow lost only 38 percent during the same period. In addition, the expanded market for fat has meant better prices for livestock producers and packers. Today, animal feeds absorb about 1.8 billion pounds of inedible animal fats a year.

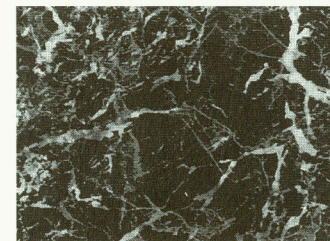
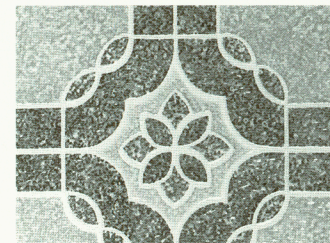
*Americans in  
1940, still happily  
unconscious of the  
health risk of high  
cholesterol levels,  
consumed more lard  
than they did  
vegetable oils.*



Using a process called epoxidation, ERRC chemist Daniel Swern modified rigid vinyl plastics to make them flexible.



*Thanks to research  
by an ERRC  
chemist, soft vinyl  
plastics grew into a  
billion-dollar  
industry. They are  
used, among other  
things, for floor tiles  
and upholstery.*



The U.S. market for edible animal fats was expanded by improvements in blended shortenings. First introduced around 1900, blends were mixtures of cottonseed oil and hard fats, such as lard and tallow. Known as lard compounds, they sold for a lower price than pure lard, then considered the shortening of choice from the standpoints of price and flavor. In the 1920's, however, hydrogenated cottonseed oil began to supplant lard in more and more U.S. kitchens, a trend stimulated by heavy advertising. Lard production and sales fell to a low level—less than 100 million pounds a year up to 1943.

In the 1940's, several publications by USDA chemists described advantages to be gained by a return to blended shortenings. Industry also contributed to a revival of interest in blends by

improving the physical characteristics of meat fats, making them more suitable as shortenings. ERRC research showed that blends of meat fats with vegetable oils resulted in products with more stability than meat fats alone, since the vegetable oils contained natural antioxidants. The joint efforts of industry and USDA chemists helped increase the consumption of blended shortenings; the commercial baking industry used large quantities. In the years 1960-65, this use of lard and beef tallow averaged 880 million pounds. Further increases came with the phenomenal growth of fast food restaurants, which used large quantities of blends for french fries.

Unfortunately for the animal fats industry, the major U.S. fast-food chains, responding to widespread public concern over



cholesterol, decided in 1990 to switch from blends to vegetable oils. Some estimate the industry loss at 300 to 400 million pounds of edible tallow a year. A number of bakers have also abandoned blends. As recently as 1985, 460,000 metric tons of edible tallow were used domestically for baking and frying; by 1989, that figure had fallen to an estimated 351,000 metric tons, and it is expected to have fallen still more in 1990 and 1991.

A number of manufacturing uses were found for animal fats. ERRC chemists in the late 1940's developed a process for preparing a purified grade of oleic acid from inedible animal fats. The improved acid was soon being made commercially by several of the world's largest producers of fatty acids. Oleic acid is converted to emulsifiers, cosmetic ingredients, and other specialty chemicals and is used in textile mills in lubricants and antistatic agents.

ERRC contract research in the early 1950's resulted in using animal fats as a flux in the hot-dip tinning of steel. To produce a more satisfactory flux, typical industrial grades of animal fats were modified by the addition of fatty acids and by hydrogenation. The new product, which proved a cheaper but satisfactory alternative to palm oil as a tinning oil, eliminated the need for government stockpiles of palm oil, resulting in considerable dollar savings to taxpayers.

In the early 1970's, ERRC scientists conducted research to modify soap in an attempt to recapture at least part of that once-valuable market for animal fats. Unmodified soap is made from fat and lye, which produces soap and glycerine. It has many virtues besides its ability to cleanse; for one thing, it degrades rapidly.

But soap has been eclipsed by synthetic detergents for laundry and other cleaning chores chiefly because it does not perform as well in cold or hard water. Hard water in many parts of the United States gets that way because of dissolved limestone. Unmodified soap and limestone salts form a grainy scum, known to chemists as lime soaps. What a team of ERRC chemists did was add a fat-based compound to keep lime soap in dispersion and to keep it from leaving scum. Not one but several

derivatives of fatty acids, alcohols, and amines were found to be effective surfactants for the purpose.

Soap containing 10 to 20 percent of a lime-soap dispersing agent turned out to be a good detergent in hard water, but the chemists decided it wasn't quite good enough. It was made even more effective by the addition of citrate and silicate to act as what detergent makers call builders. After many washing tests, the chemists settled on a 65-15-20 formula for soap, lime-soap dispersing agent, and builder. So constituted, the new detergents worked well in hard, soft, hot, and cold water. In various tests, they outperformed the most effective synthetic detergents on the U.S. market. Further, they contain no objectionable phosphates and are nontoxic to humans, domestic animals, wildlife, and algae. But while the new detergents are now manufactured in other countries, only one U.S. manufacturer has begun to make them—for use so far only in one brand of body soap.

Other ERRC developments have emerged from research on fatty acids. A single-step reaction, known as alpha-anion activation, has produced a wide variety of fatty acid derivatives with potential commercial application. They include a new insect repellent of interest to the U.S. Army and a chemical key to making antidiabetic drugs. Before the new method was invented, the chemicals were either derived through expensive processes or were unattainable by any means.

Eastern lab scientists over the years have developed many innovative methods for analyzing and characterizing the chemical constituents of fats and oils. Many of these methods were tested by other laboratories before their adoption as standard analytical procedures. Once adopted, a method can be used by industry to measure the quality of products containing fats and oils; by trade groups to ensure conformity to international standards, and by researchers to assess chemical changes in fats and oils during processing.

Eventually, several analytical methods were miniaturized at the ERRC so that fatty components of blood and tissue, such



*The most important use for surplus animal fats found by ERRC is as additive to animal feeds, including dog food.*



as cholesterol, could be investigated. The first analyses of atherosclerotic plaques were performed in collaboration with Philadelphia medical schools using ERRC methods.

Edible tallow is one of the cheapest of fats and is in oversupply in the United States; cocoa butter, used in chocolate, is one of the most expensive and has to be imported. With this in mind, ERRC chemists and engineers have devised ways to separate tallow into fractions of greater commercial value than whole, unfractionated tallow. Several fractions have potential value for the food industry. One has properties almost identical to those of cocoa butter.

Technologists made chocolate bars from the tallow butter, and they report that the candy won favorable scores from ERRC and chocolate industry taste panels. An ERRC pilot plant for making tallow fractions has been scaled up and made continuous, and both the processes and products have been patented in the United States and several other countries. (See also the next section, "Cottonseed Oil and Meal," for a description of related work at New Orleans.)

As the nineties begin, ERRC is conducting research to modify surplus oils with enzymes. Lipases are enzymes that operate on fats, or lipids, which include fatty acids and glycerol. Lipases are being used in laboratory experiments as catalysts to convert low-grade fats and oils into higher grade raw materials. The objective is to produce clear, pure fatty acids and glycerol from spent, discolored, smelly fats and oils. If successful, the clean products can be sold to make cosmetics, drugs, inks, lubricants, and synthetic rubber.

Using a process called hydrolysis, ARS scientists are working on improving a piece of equipment they invented known as an immobilized lipase membrane reactor. Several patents have already been issued in connection with the work, and results—pure, clean fatty acids—are so far promising. A pilot-scale reactor is being built to demonstrate the commercial practicality of the lipase enzyme reactor.